Specific Heat and Thermal Transport Measurements by Contactless Modulation Calorimetry in a Reduced Gravity Environment

R.K. Wunderlich, A. Sagel, and H.-J. Fecht Institut fur Metallforschung und Technologie Technische Universität Berlin 10632 Berlin, Germany

Investigation of the thermodynamic properties of glass forming metallic alloys over a wide range of liquid undercooling requires a contactless technique in order to avoid heterogeneous nucleation induced by contact with container walls. In particular, knowledge of the specific heat allows determination of the thermodynamic functions in the undercooled melt such as Gibbs free energy relevant for the stability of the undercooled melt and nucleation kinetics. Contactless modulation calorimetry is based on positioning a specimen in a quadrupole radio-frequency field and heating with a dipole field. Temperature is measured by a well calibrated pyrometer. The dipole field can be modulated either in amplitude or power. A calibration scheme was developed allowing quantitative evaluation of the specific heat in the undercooled melt from the measured temperature response. An external and internal relaxation time can be determined from measurements of the frequency dependence of the temperature response either in amplitude or in the phase shift between the modulated heating field and specimen temperature. The latter also provides a direct verification of the prevalence of adiabatic conditions in which case the specific heat can be directly evaluated from the temperature response without further corrections. The external relaxation time and thus the total hemispherical emissivity can be more directly determined from measurements of the temperature response following a small step function change in the heating power input while an effective thermal conductivity can be evaluated from the high frequency response. This method has been applied under microgravity conditions to the measurement of the specific heat of binary metallic glass forming Zr based eutectic alloys and will be applied in the very near future to bulk metallic glass forming four and five component alloys.